

Ocean Model Development for COAMPS

Paul J. Martin,

NRL Code 7322

Stennis Space Center, MS 39529

Phone: 601-688-5447 Fax: 601-688-4759 email: martin@nrlssc.navy.mil

Award Number: N0001497WX30197

LONG-TERM GOALS

Develop a coupled ocean-atmosphere prediction system that can be used for hindcasting and forecasting coastal environments. This system is referred to as the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). The atmospheric component of this system is fully functional and was developed by the Atmospheric Dynamics and Prediction Branch of the Naval Research Laboratory (NRL) in Monterey.

OBJECTIVES

The objectives of this project are (1) to develop an ocean model that contains some of the best features of existing coastal ocean models and will meet the Navy's needs for conducting simulations and predictions in littoral environments and (2) to fully couple that model with the atmospheric model within the current COAMPS program architecture.

APPROACH

COAMPS consists of coupled ocean and atmospheric models. Two ocean models have been used with COAMPS. One (the first) was developed for use in deep water and does not incorporate variable bottom depth. The other is the Modular Ocean Model (MOM) developed by the Geophysical Fluid Dynamics Laboratory (GFDL) at Princeton. MOM has some limitations for coastal use, and the MOM program is not presently in a form that allows use of the full flexibility for which the COAMPS program architecture was designed.

For coastal applications, an ocean model is needed that can accommodate the wide range of environments and processes that can be encountered in coastal regions, including complex coastlines and bathymetry, tides and storm surge, river outflows and coastal runoff, and flooding and drying of low-lying coastal areas. The purpose of this project is to develop an ocean model to provide these capabilities. The ocean model being developed in this project will be referred to as the Navy Coastal Ocean Model (NCOM).

Based on results from the Coastal Model Comparison study conducted by the NOMP Ocean Model Performance and Evaluation Project at NRL, it was proposed that the ocean model to be developed for COAMPS consist of the following main elements: (a) the basic physics and numerics of the Princeton Ocean Model (POM), (b) the combined sigma/z-level vertical grid system used in NRL's Sigma/Z-level Model (SZM), (c) a program structure fully consistent with COAMPS. and (d) some additional capabilities and refinements.

Report Documentation Page			Form Approved OMB No. 0704-0188		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 30 SEP 1997	2. REPORT TYPE		3. DATES COVERED 00-00-1997 to 00-00-1997		
4. TITLE AND SUBTITLE Ocean Model Development for COAMPS			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S)			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Research Laboratory, Code 7322, Stennis Space Center, MS, 39529			8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 4	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

A combined sigma/z-level grid system provides some additional flexibility over a sigma coordinate system in setting up a vertical grid for a particular region. With the combined grid system, sigma coordinates are used down to a user-specified depth, and z-levels are used below. The z-level grid, which is generally more robust in regions of steep bottom slopes than sigma coordinates, can be applied at the depths below which steep bathymetry may cause difficulty. The combined grid system also allows comparisons to be made between sigma and z-level simulations to assess the extent of differences.

COAMPS has a very specific code architecture that is mainly defined by two attributes: (1) all model variables are passed via subroutine argument lists rather than by common blocks and (2) all model array space is dynamically allocated at run time. The reason for these attributes is to allow the same model code to calculate different nested grids for both the atmospheric and ocean models within a single program, and to avoid having to recompile the program for different simulations with different grids. The ocean model to be developed for use in COAMPS needs to be structured to be consistent with the COAMPS code architecture. Most existing ocean model codes are not structured in this way.

It was desired to include some additional capabilities in NCOM that are not currently available in POM. These include an explicit source term to simplify inclusion of river inflows, forcing by the local tidal potential and the surface atmospheric pressure gradient, and the choice of either the Mellor-Yamada Level 2.5 turbulence closure scheme as used in POM or the simpler and more efficient Mellor-Yamada Level 2 scheme.

Some additional features that were desired for NCOM will be delayed for a later update in order that coupling of NCOM to COAMPS can be begun in early FY98. These features include truncation of the bottom grid cell on the z-level part of the grid to the bathymetry, flooding and drying, and the option of an advection scheme that upwinds at fronts to reduce noise caused by numerical overshooting of the advection terms.

WORK COMPLETED

A Fortran code for NCOM has been written and tested, and a separate version of the code has been developed that is compatible with the COAMPS architecture, i.e., that includes dynamic allocation of array space and passes all model variables through subroutine argument lists.

RESULTS

A Fortran program for NCOM has been developed and tested. This code is described by the following features:

Model physics - primitive equation, incompressible, free surface, hydrostatic, Boussinesq, Laplacian horizontal diffusion, horizontal eddy coefficients calculated based on minimum value and a maximum grid-cell Reynolds number, option of Mellor-Yamada Level 2 or Level 2.5 vertical mixing scheme, explicit source term in all equations to simplify river inputs, forcing included for local tidal potential and atmospheric surface pressure, capability of running with cyclic boundaries in either or both directions, and seamless restart capability.

Model numerics - C-grid, leapfrog in time with Asselin filter to suppress timesplitting, 2nd-order, centered spacial finite differences, curvilinear horizontal grid, combined sigma/z-level vertical grid, implicit treatment of the free surface, and implicit vertical mixing.

It was desired to provide the option for a split-explicit treatment of the free surface as is used in POM, as well as an implicit treatment. However, an inconsistency was noted between the three-dimensional and depth-averaged fields on a z-level grid that might cause some inconsistency between forcing terms calculated with three-dimensional and depth-averaged variables. Hence, a split-explicit treatment of the free surface was put off until the issues involved could be more carefully investigated.

A separate version of NCOM has been developed that is compatible with the program architecture of COAMPS. In this version of the model, all the model array space is dynamically allocated and all model variables are passed via subroutine argument lists rather than in common blocks. The two versions of NCOM were verified to give similar results. (Bit-for-bit agreement was verified for some steps in the conversion, but bit-for-bit agreement was not obtained for the final converted code, presumably due to re-ordering of some calculations by the Fortran 90 compiler on our Sun workstations when the program was converted to use dynamic memory allocation.) It was also verified that the COAMPS version of NCOM can calculate different grid meshes simultaneously within a single program, a preliminary step to developing a flexible nesting capability.

The two main tasks required to couple NCOM with COAMPS, which are being addressed in FY98, are to develop a nesting capability for the ocean model that allows several levels of nesting, and to couple the ocean model with the atmospheric model within COAMPS.

IMPACT/APPLICATIONS

The ocean and the atmosphere are strongly coupled in coastal regions, and a combined ocean-atmosphere modeling system is frequently the optimal means of hindcasting and forecasting coastal areas. COAMPS is being developed by NRL to provide a high-resolution, coupled atmosphere-ocean prediction capability. The payoff from this project will be a functional and flexible ocean model for coastal ocean prediction that is fully integrated with COAMPS.

TRANSITIONS

The ocean model developed in this project will be used for coupled ocean/atmosphere modeling via COAMPS as well as for stand-alone ocean modeling.

RELATED PROJECTS

NRL-Monterey is currently in the process of adapting MOM and POM to COAMPS, and is also being funded by NOMP to assist in the development of NCOM and the installation of NCOM into COAMPS.

A joint project between NRL-Stennis and NRL-Monterey, entitled "Ocean Data Assimilation for COAMPS", is working to develop an ocean data assimilation system for COAMPS.

REFERENCES